Evaluation of the quality of Langoustines after being killed by the Crustastun

A Scientific Report by

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Introduction

The Crustastun is a device designed to administer a lethal electric shock to shellfish (such as lobsters, crabs, and crayfish) before cooking, to avoid boiling a live shellfish (**www.crustastun.com**). It works by applying a 110 volt, 2-5 amp electrical charge to a shellfish.

It is stated by Simon Buckhaven, the inventor of the CrustaStun, that it is not only a fast and efficient way of killing a lobster, but that as it reduces the stress that the animals goes through, and also the quality of the meat in terms of texture and flavour are improved.

An evaluation of the effects of using the Crustastun to kill langoustines (*Nephrops norvegicus* (L.)) on established quality measures has been performed using a set of assays developed by the Langoustine Lab at the University of Glasgow. For comparison, langoustines killed by holding them continuously on ice have also been evaluated.

A   **B**

Figure 1. A. The Crustastun Prototype I. **B.** Langoustines on ice after being electrocuted in the Crustastun.

Methods

Capture, holding and transportation

Langoustines (*Nephrops norvegicus*) were caught by otter trawl in the Clyde Sea area on two occasions, (the 17/08/2007 and 23/10/2007) by the vessel RV Aplysia. Once on board, animals were held in running seawater and arrived to the University Marine Biological Station Millport (UMBSM) within 4 hours, at which time they were still alive and vigorous.

The Crustastun process

From the trawl catch obtained on 23/10/07, once in the UMBSM, a group of 30 animals was killed using the Crustastun Prototype I machine with factory settings (110 volt, 2-5 amp delivered for 5s − lobster symbol). Seven cycles of operation were performed with 4-5 animals per cycle. Before and after this procedure, both photographs and thermal images (Fluke Ti20 thermal imager) of the animals were taken, and the temperature of the brine in the Crustastun chamber was recorded. In addition, samples of the brine solution were taken from the chamber before use, and also after 7 cycles of operation, for analysis of bacterial content.

Quality assessments

From the trawl catch obtained on 17/08/07, once in the UMBSM, animals were separated into 2 groups (each of 50-60 animals). One group of animals was killed using the Crustastun Prototype I machine with factory settings (110 volt, 2-5 amp delivered for 5s – lobster symbol). Twelve cycles of operation were performed with 4-5 animals per cycle. The other (Control) group of animals was placed directly on ice. Ten samples of tail meat were taken from animals immediately after being Crustastun-killed, and the same number of samples was taken simultaneously from animals of the ice-killed group ("fresh"). After that, all the remaining animals from the two groups were transported on ice to the University of Glasgow where they were kept at a temperature of 0-2ºC for up to 7 days. Further assessments were made and samples of tail meat were taken on days 1, 3, 5 and 7. At each time point some or all of the following parameters were measured:

- Visual assessment of the animals

- Melanosis score

- Measurement of the nucleotide breakdown products (ATP, ADP, AMP, IMP, INO, HX)

- The K-value (a freshness indicator) calculated the ratio of nucleotide breakdown products

- The pH of the meat

- The bacterial load in the meat (measured as total bacteria counts, H_2S producers, luminescent bacteria and *Pseudomonas* sp. bacteria)

- The nitrogenous breakdown product trimethylamine oxide (TMA)

- From the trawl catch of 23/10/07, samples from Day 1 from both the Crustastun-killed and the Ice-killed groups were frozen, and at a later date were assessed by an independent sensory panel trained previously to evaluate the sensory properties of langoustine meat.

The principles and methods of the quality assays

Visual Assessment

A visual assessment was used that is based on five different parameters (appearance of head; appearance of claws; appearance of upper-side of tail; appearance of under-side of tail; odour), each of which is allocated four demerit scores. The Tables used for the visual assessment of the animals are presented in the Appendix 1.

Melanosis score

Melanosis (also known as enzymatic browning or blackspot syndrome) causes a blackening of food produce surfaces, shells and membranes and affects fruits, vegetables and seafood. In seafood, melanosis occurs primarily in crustaceans and is a major problem during post-harvest storage. The blackening is caused by the action of the enzyme polyphenol oxidase (PPO). Several stress-related factors can activate the PPO enzyme, such as the capture process, rough handling and in general 'traumatic' events (Bartolo and Birk, 1998). Moreover, once melanosis is triggered and becomes established several factors affect the rate of blackening, such as pH and

temperature. The Tables used for the scoring of melanosis in langoustines are presented in the Appendix 2.

Measurement of the nucleotide breakdown products

The amounts of the nucleotide breakdown products ATP, ADP, AMP, IMP, INO and HX in langoustine tail meat samples were determined using high performance liquid chromatography (HPLC). A supernatant of muscle homogenate was extracted, and analysed by HPLC following a protocol modified by Ryder (1985) using a reverse-phase column.

Freshness Index (K-value)

The K-value is one of the most useful indicators to evaluate fish and shellfish freshness (Connell, 1980). Strong correlations between sensory loss of freshness and increase in K-value have been found in many fish species. The K-value is calculated from the concentrations of ATP, the main metabolic energy source in muscle, and its breakdown products. The degradation of ATP follows a general pathway:

$$ATP \longrightarrow ADP \longrightarrow AMP \longrightarrow IMP \longrightarrow INO \longrightarrow Hx$$
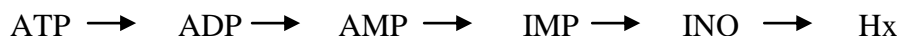
The first steps of this degradation are catalyzed by endogenous tissue enzymes (autolytic phase) while further stages are slower and besides tissue enzymes they also involve bacteria (bacterial phase). Taken together, the concentrations of all these compounds make it possible to calculate the K-index or K-value, as described first by Saito (1959) and later by Ryder (1985):

$$K\text{-index} = \frac{[Ino+Hx]}{[ATP+ADP+AMP+IMP+Ino+Hx]}$$

The higher the value of the K-index, the greater the loss of freshness. In several fish species a K-value of 20% has been set as a freshness limit, although this index is species-dependent and therefore does not apply to all fish species. The K-index is widely used today; for example it is a standard fish freshness index in Japan. Furthermore, some of these compounds are related to different tastes. In this sense,

IMP has been described to give a nice, meaty taste to food and fish in particular while Hx has been attributed to give a bitter-off taste to fish products. In many fish species these changes correlate well with sensory assessment.

The pH of the meat

Low values of muscle pH in live or early post-mortem stages indicate ante-mortem exhaustion of reserves and gradual formation of anoxic conditions in the muscle. Under these conditions, an accumulation of lactic acid and other acidic products as a result of glycolysis (the breakdown of glycogen) produces low pH values. In this study, the pH of langoustine tail meat samples was determined from muscle homogenates using a standard semi-micro pH electrode (Jenway).

The bacterial load in the meat

To count the number of marine (psychtrophic) bacteria in langoustine tail meat, samples of the tail meat with added sterile sea water containing bacterial peptone were homogenized, serially diluted and plated onto marine agar plates with added marine broth (for total marine bacteria) or with added iron (for H_2S-producing bacteria). Plates were incubated at $20^{o}C$ for 48h, and the colonies were counted and converted to values of colony forming units per gram (cfu g^{-1}). For H_2S-producing bacteria, the total of black colonies on the iron agar plates was determined. The number of luminous bacteria strains was also determined by counting the number of luminous colonies on the MIA plates in a dark room after 48 h. For the determination of *Pseudomonas* sp., an agar with an added selective 'CFC' supplement was used.

The nitrogenous breakdown product trimethylamine oxide (TMA)

Decomposition of some non-protein nitrogenous compounds during post-mortem metabolism causes undesirable properties such as the loss of freshness and the development of putrefaction. Among these compounds is TMA, a volatile odorous

compound that gives a fishy or ammonia-like smell to raw fish products. Many bacteria are capable of producing TMA that comes from the reduction of TMAO. In this study, the TMA in samples of langoustine tail meat was determined using the method of Dyer (1959) as modified by Stroud *et al.* (1982). Seven different biogenic amines (putrescine, cadaverine, histamine, tyramine, agmatine, tryptamine and spermidine) were also analysed, although the results are not presented in this report.

Sensory Evaluation

In order to assess if the Crustastun had any impact on cooked langoustine tail meat, an independent sensory assessment was performed in the Food Innovation Institute at the Midlothian Innovation Centre, Edinburgh. A trained Panel performed the Quantitative Descriptive Analysis (QDA) method to profile each langoustine sample in terms of its sensory attributes related to aroma, appearance, texture and flavour. For each sensory attribute of this QDA test, a two-anchored linear scale (0-10) was used, in which the score of 5 is the mid-point. This scale is objective and has nothing to do with the like or dislike of a given panelist. The trained Panel was also asked to provide a subjective score for their 'degree of like or dislike' to obtain the 'overall liking' on a linear scale (0-10). On this scale, 0 equals extremely disliked, 10 equals extremely liked and 5 equals the mid-point.

Samples from animals killed with the Crustastun or killed on ice were frozen on Day 1 and then stored at -22˚C until they were sent on dry ice to the Sensory Testing Laboratory. Sample preparation involved thawing the animals, and boiling the tails for 3 minutes to ensure core temperature of 75˚C (in compliance with EU regulations) and then peeling the tails to obtain the meat. Sensory evaluation sessions were carried out by a trained professional panel of ten members, and all tests were conducted and all the data were gathered and analysed using a specialised computer software package (FIZZ) and Microsoft Excel. For information on the FIZZ specialised software for sensory evaluation see http://www.biosystemes.com.

Results

The Crustastun process

The Crustastun process (110 volt, 2-5 amp delivered for 5s – lobster symbol) was found to reliably kill all the animals (up to 5) placed in the chamber, as judged by the fact that they showed no further body or limb movements after treatment. The stunning process was found in most cases to induce a flexure of the tail (Figure 2), presumably due the occurrence of tetanic contraction of the tail flexor muscles.


Figure 2.   A. Three live langoustines mounted in the Crustastun chamber. **B.** The same three langoustines immediately after the Crustastun process

Before being Crustastun-killed, the animals landed on 23/10/2007 had body temperatures of 12.5-13.0ºC, and the brine in the Crustastun chamber had a temperature of 15-16ºC. After being electrocuted, the temperature of the animals increased significantly, especially in the region of dorsal cephalothorax or "head" (the part of the body that would have been in contact with the upper electrode in the lid) (Figure 3). The temperature of the dorsal surface of the cepahalothorax reached around 24-27ºC on average (with maximum temperatures measured of around 30ºC). In some cases (Figure 4) the Crustastun process also resulted in an increase in the temperature of the dorsal side of the abdomen ("tail"), but such increases were never as pronounced (the highest recorded being around 22ºC) and in many cases tails were not affected at all. Thermal images of the transverse section of the cephalothorax (Figure 5) reveal the thermal gradient from the dorsal surface to the ventral surface. This indicates that it is predominantly the upper side of the cephalothorax that is

affected by the increase in temperature, while the ventral side suffered practically no change.

After 7 cycles of operation, in which a total of 30 animals were killed, the temperature of the brine in the Crustastun chamber increased by only 1ºC (from 16ºC to 17ºC), However, it is probable that this temperature increase would have been larger if more animals had been Crustastun-killed over a larger number of cycles, and/or over a shorter period of time or if ambient air temperature had been higher.
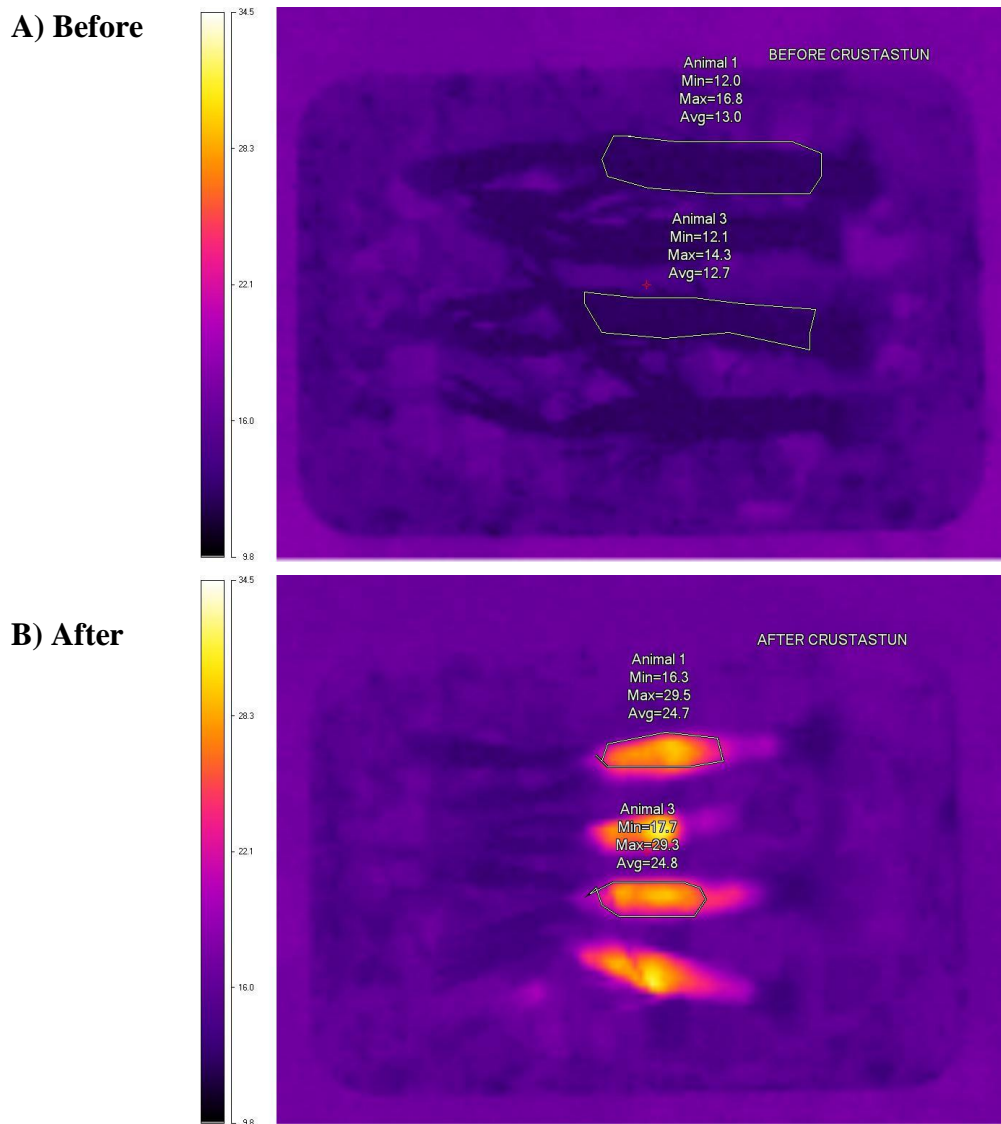
A) Before

B) After

Figure 3. Thermal images of a group of four langoustines A) before and B) after being killed using the standard Crustastun procedure. Values refer to the outlined areas.
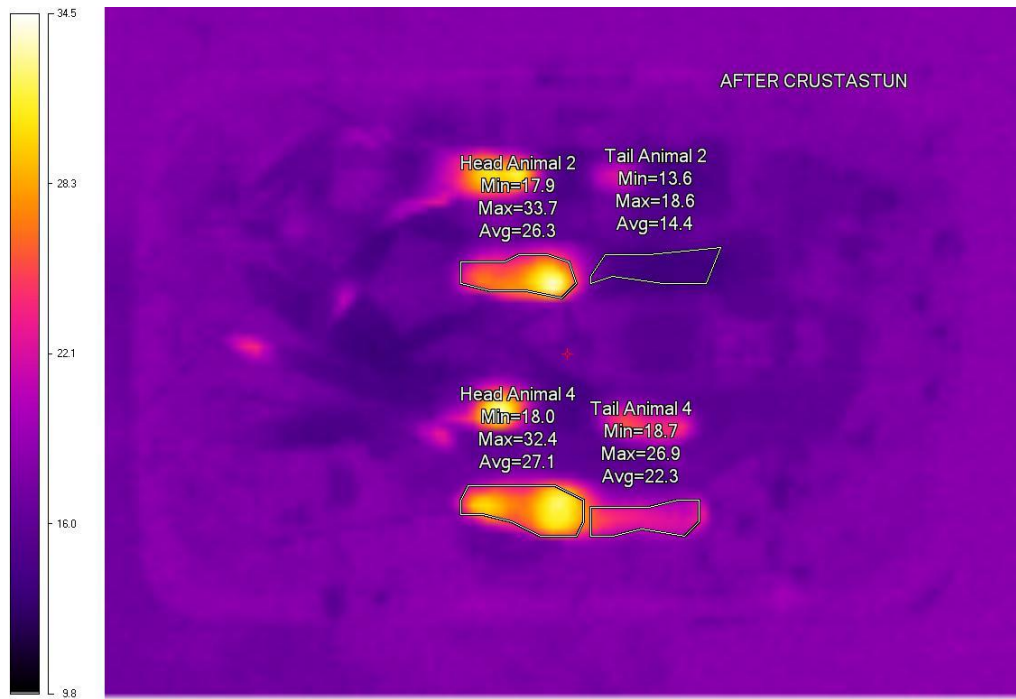
Figure 4. Thermal images of a second group of four langoustines after being killed using the Crustastun machine. In this case there was some change in the temperature of at least two of the tails. Values refer to the outlined areas.

A) Before　　　　　　　　　　　　　　**B) After**

Figure 5. Thermal images taken through a transverse section of the cephalothorax ("head") A) before and B) after being subjected to a standard Crustastun. procedure. Values refer to the outlined areas.

Quality measures

Visual assessment

Animals killed with the Crustastun had visual assessment (QIM) scores (as per the scheme in Appendix 1) very similar to those of animals killed on ice, both on Day 1 (first assessment) and also up to 7 days (Figure 6).
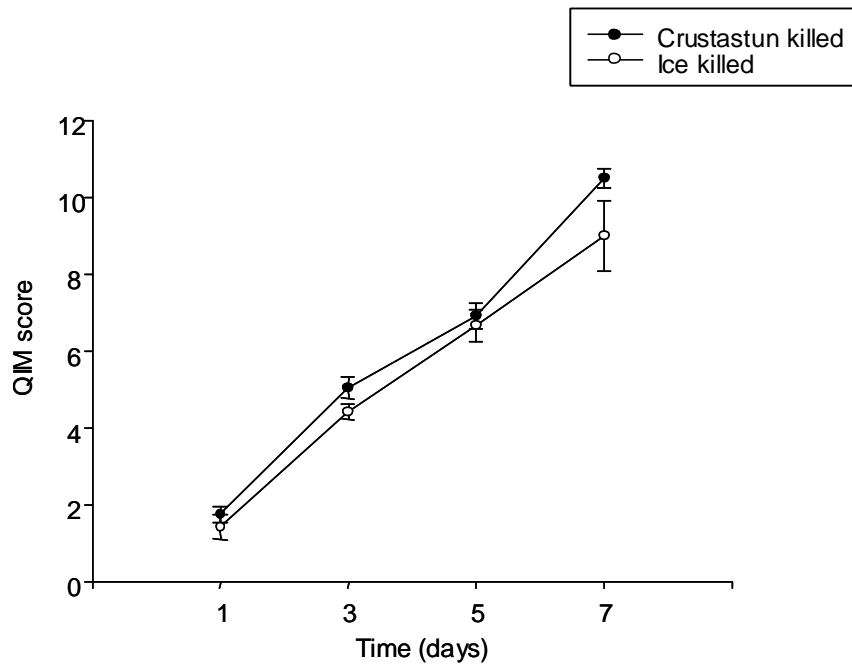
Figure 6. Scores obtained from visual assessment of langoustines killed with Crustastun or ice and stored at 0-2ºC for up to 7 days. Values are the mean ± S.E.M. of ten different animals.

Melanosis Score

In terms of melanosis development (using the scoring scheme in Appendix 2) it was found that animals killed with the Crustastun developed black discoloration (melanosis) in the dorsal cephalothorax region ("head") more rapidly, compared to the animals killed on ice (Figure 7). This effect was initially indicated on Day 1 (first assessment) and became clear after 3 days of storage (Figure 8). However this effect of the Crustastun on the development of melanosis was only observed in this one region of the body, while values similar to those of the ice-killed Control group were recorded for the other parts of the body, i.e. the first (clawed) legs, the ventral cephalothorax & pereiopods, the pleopod appendages, tail and tail fan (Figure 7).

Dorsal cephalothorax

First clawed legs

Crustastun killed
Ice killed

Ventral cephalothorax & pereiopods

Pleopods

Tail

Tail fan
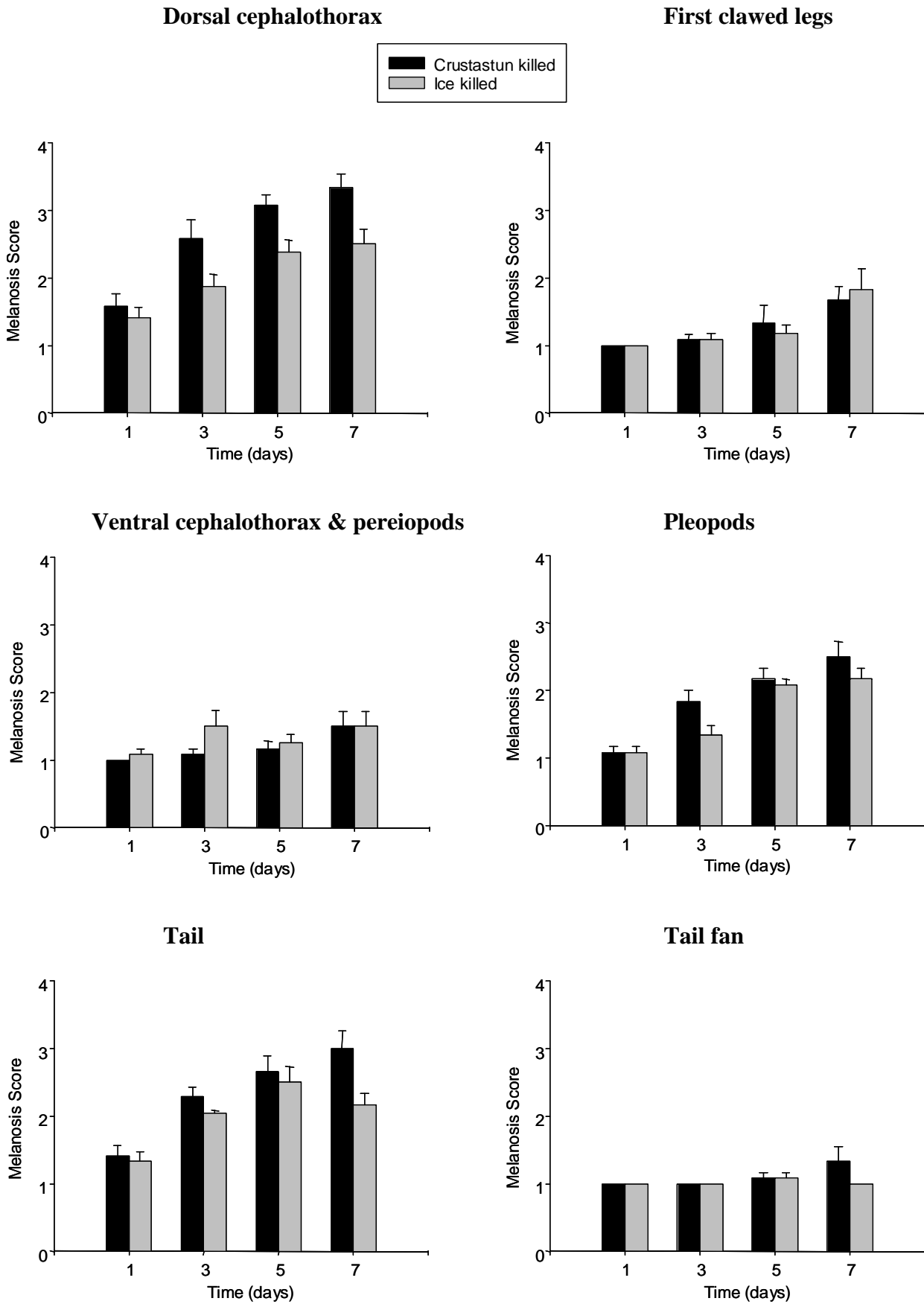
Figure 7.   Melanosis score in langoustines killed with Crustastun or ice and stored at 0-2ºC for up to 7 days in different parts of the body. Values are the Mean ± S.E.M. of ten different tails.

Figure 8. Melanosis development in langoustines on Day 3 after being killed using Crustastun (left group) or ice (right group).

Breakdown of nucleotides

The degradation of ATP and its breakdown products was analysed and the results are shown in Figure 9. In both groups AMP was the main nucleotide immediately after the animals were killed, which is consistent with results previously obtained from animals captured by trawling. On Day 1, IMP was the main nucleotide in Crustastun-killed animals, while AMP was still high in ice-killed animals. These results indicate that on Day 1 the processes of autolysis were more advanced in Crustastun-killed animals compared to ice-killed animals.

The fact that IMP increased sooner in Crustastun-killed animals could be advantageous in terms of the taste of meat of these animals over the early stages of storage (first 24 hours), if, as reported for several fish species, IMP gives the enhanced taste to langoustine meat. This possibility was separately evaluated by the independent sensory panel.

The differences between the nucleotide profiles of the two groups were only observed in the early storage stages, but from Day 5 onwards there was no difference between them. For instance, Hx concentrations (related to a bitter-off taste) were very similar

between Crustastun-killed (0.33 ± 0.09 µmol/g) and iced-killed animals (0.34 ± 0.01 µmol/g) at the end of the 7 day storage period.

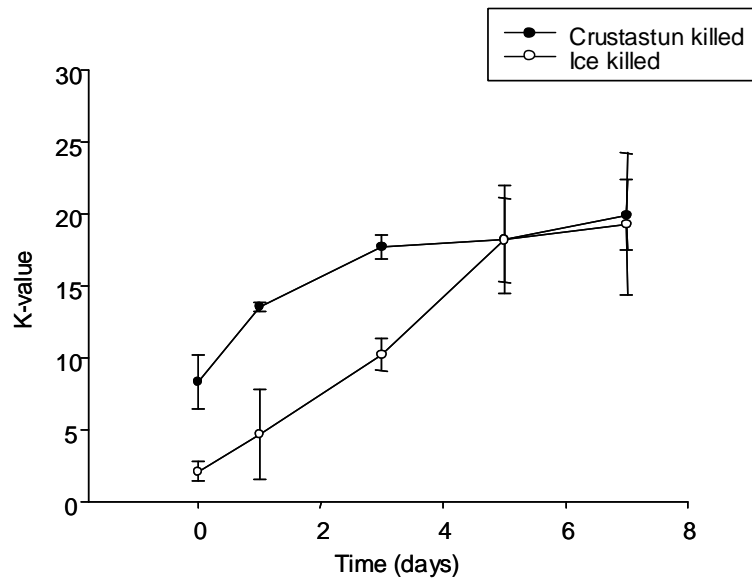**A) Crustastun-killed**   **B) Ice-killed**
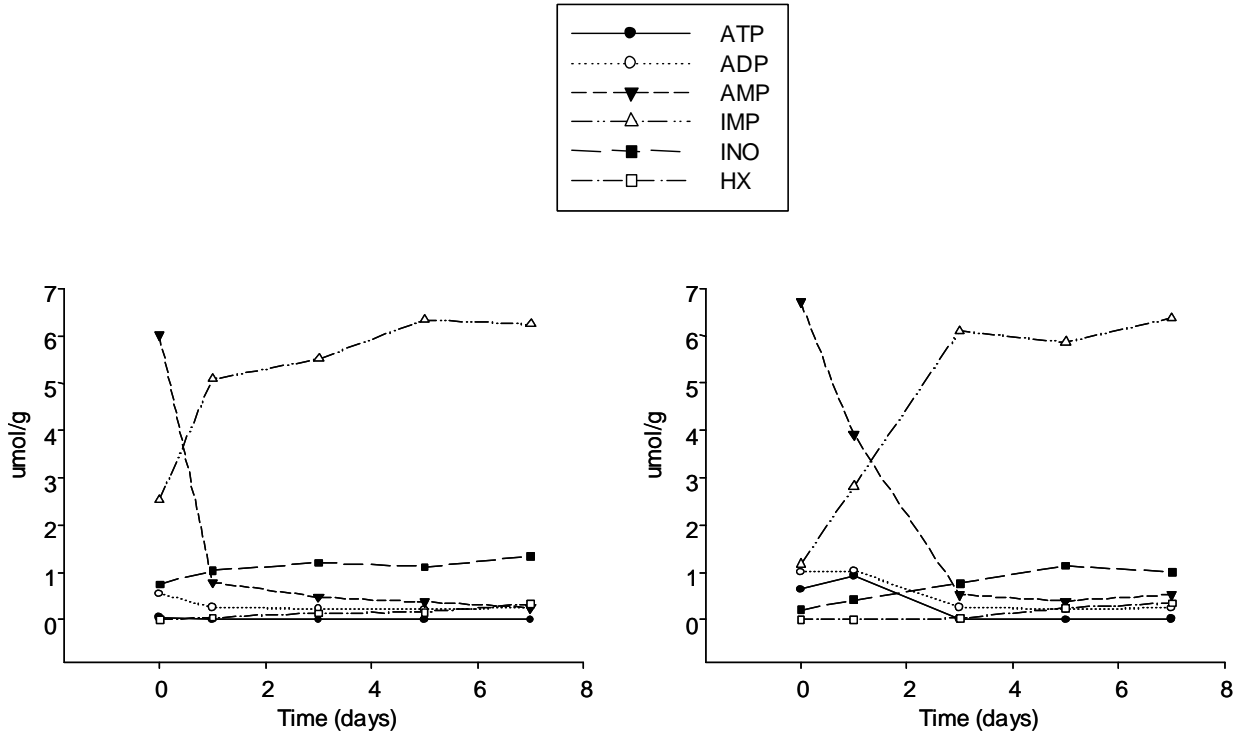
Figure 9. Nucleotide profiles in langoustine meat during ice storage after being killed using A) Crustastun or B) left on ice. Values are the mean of three different determinations.

The Freshness Index (K value)

The K-values calculated from the concentrations presented in Figure 9 were initially higher in Crustastun-killed animals than in ice-killed animals (Figure 10), and this difference persisted up to Day 5.

Our interpretation of this difference is that there was a more rapid autolytic phase after Crustastun killing. Moreover, the eventual similarity of the curves can be ascribed to there being a similarity in the bacterial phase of spoilage in the two groups.
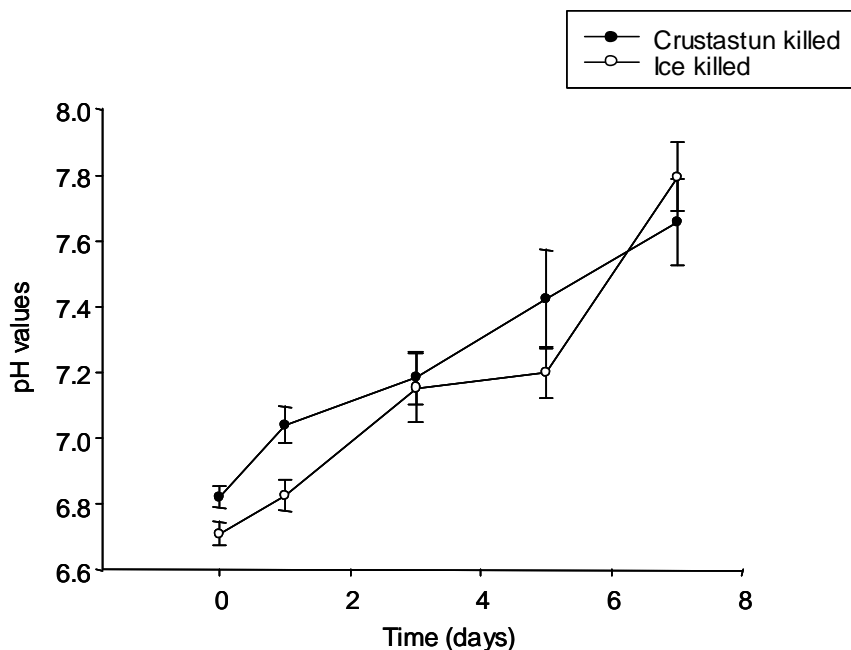
Figure 10. K-values in Langoustine meat during ice storage after being killed using different methods. Values are the mean of three different determinations.

The pH of the meat

When sampled fresh, immediately after landing, the pH values in the tail meat of both groups was lower than obtained from aquarium held animals (the meat of which typically has a pH of around 7.4). This difference is explicable by the fact that the animals used in the present trials had been obtained by trawling, which is known to cause elevated lactic acid production. Moreover, the Crustastun-killed group had a mean value of 6.71, while the pH in the tail meat of the ice-killed group had a mean pH value 6.82 (Figure 11). These values are significantly different, suggesting that the processes of glycolysis were reduced in Crustastun-killed langoustines.

On Day 1, the pH values in the tail meat of both groups had increased, but the Crustastun-killed animals continued to have a higher pH than those of ice-killed animals. This again indicates that the post-mortem autolytic processes were more advanced in this group, with the consequent breakdown of nitrogenous compounds leading to increases in the pH. This result is consistent with the measurements of the nucleotide breakdown rates. By comparison, the pH of the tail meat of animals killed on ice remained lower, indicating that they were in earlier stages of post-mortem change. Thereafter, in both groups the pH increased steadily with storage time, and from Day 3 onwards there was no difference between them in this measure.

Figure 11. Changes in muscle pH in langoustines during ice storage after being killed using Crustastun on left on ice. Values are the mean ± S.E.M. of ten different animals.

We interpret the results of the nucleotide breakdown rates and the changes in muscle pH, to mean that the action of the Crustastun kills the animals almost instantaneously, and this electrocution suppresses glycolytic activity leading to an earlier onset of the post-mortem autolytic processes. As a consequence, the condition of the meat in Crustastun-killed animals is similar in these terms to that of the meat of ice-killed animals at a time point around 2 days later.

Bacterial load in the meat

The load of psychotrphic marine bacteria in the meat was obtained by plating muscle homogenates onto marine iron agar plates (Figure 12). Crustastun-killed animals had significantly lower total bacterial numbers than ice-killed animals on both Day 1 and Day 3 of storage. These results indicate that up to Day 3 the Crustastun process delayed the growth of internal psychotrophic bacteria. However, this effect was not very strong, and bacteria numbers from Crustastun-killed animals later increased to be the same as in ice-killed animals by Day 7. This suggests that there might be no actual shelf-life extension induced by killing the animals using Crustastun.
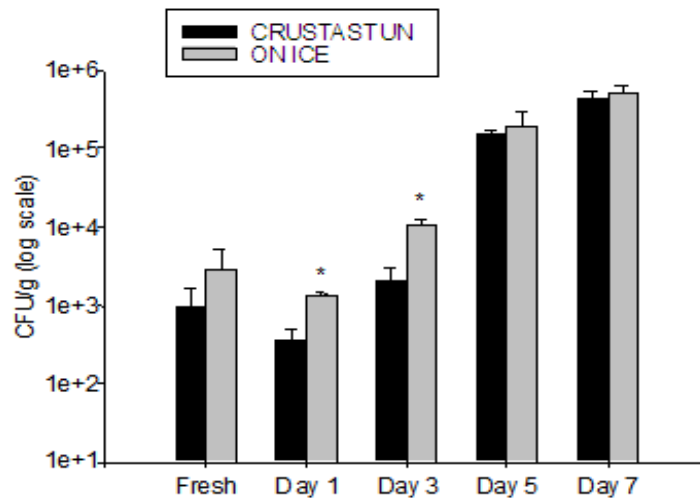
Figure 12. Changes in total bacteria counts measured on marine agar for langoustine meat during ice storage after being killed using different methods. Values are the mean ± S.E.M. of three different determinations (3 tails were pooled for each determination). Asterisks indicate statistically significant differences.

Separate determinations of the numbers of H_2S producing bacteria and of luminescent bacteria produced no differences between Crustastun-killed and ice-killed groups (data not shown). However, Interestingly, *Pseudomonas* sp. bacteria were found in higher numbers in Crustastun-killed animals, measured directly after the stunning process (Figure 13).
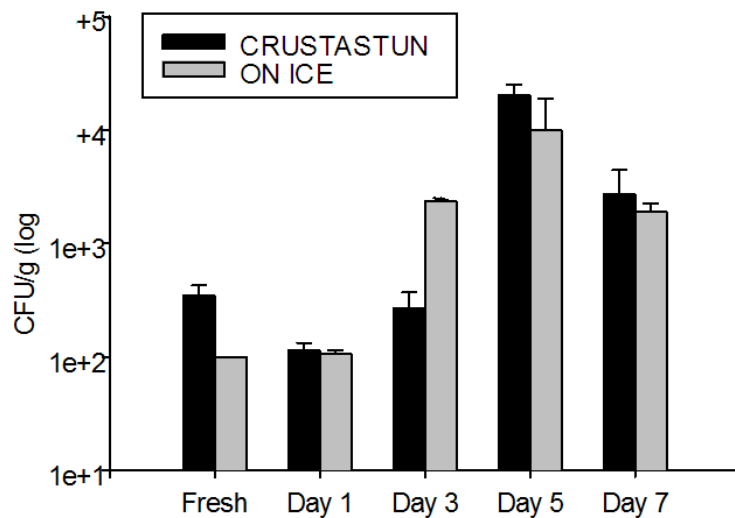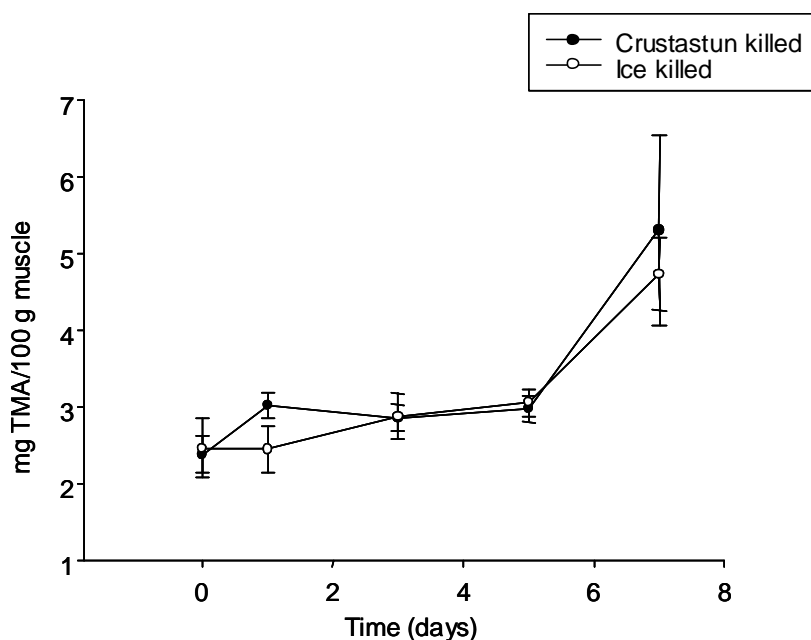

Figure 13. *Pseudomonas* Sp. bacteria in langoustine meat during ice storage after being killed using different methods. Values are the mean ± S.E.M. of three different determinations (3 tails were pooled for each determination).

When transferred to ice storage, this difference in *Pseudomonas* numbers between the Crustastun-killed and ice-killed animals disappeared or even reversed, although both then showed a pattern of increasing numbers (Figure 13). The finding of higher *Pseudomona*s sp. numbers initially in Crustastun-killed animals may have been due to the accumulation of these bacteria in the brine in the Crustastun chamber over repeated cycles of operation. This possibility was therefore tested in a separate trial (below).

Trimethylamine (TMA) concentration

Trimethylamine (TMA) is a product of bacterial spoilage, and was measured to assess the possibility that the lower bacterial numbers found on Days 1-3 in Crustastun-killed animals reduced their later spoilage activity. The results show that TMA concentrations were closely similar in the Crustastun-killed and ice-killed groups over the whole period of storage, and moreover that the amount produced did not begin to increase until Day 5 in each group (Figure 15).


Figure 15. TMA concentration in langoustine meat during storage after being killed using different methods. Values are the mean ± S.E.M. of four different determinations.

We interpret these results to indicate that the method of killing did not affect the production of TMA during subsequent ice storage. Therefore, the lower levels of

bacteria that were found on Days 1 and 3 in Crustastun-killed animals did not affect production of TMA significantly. These results suggest that either the reduction in bacteria was not large enough to change the TMA levels or that the bacteria species affected by Crustastun were not TMA producers. Measures of other non-protein nitrogenous compounds (biogenic amines) that are known to be produced by bacterial action provided essentially the same result (data not shown). Our conclusion is therefore that the bacterial phase of spoilage is little affected by Crustastun killing, and that differences found in total bacteria counts immediately after this treatment may not be relevant in terms of increasing the shelf-life of the product.

Accumulation of bacteria in the brine within the Crustastun chamber

In conjunction with the trial on 23/10/2007, in which 30 langoustines were Crustastun-killed in 7 cycles of operation, samples of the brine in the Crustastun chamber were collected at the start and at the end of the trial. The bacterial load in each water sample was analysed in terms of the total counts, and also specifically for *Pseudomonas* sp.. The results (Figure 16) indicate that the chamber contained more bacteria in total and *Pseudomonas* sp. in particular after the trial compared to before it.
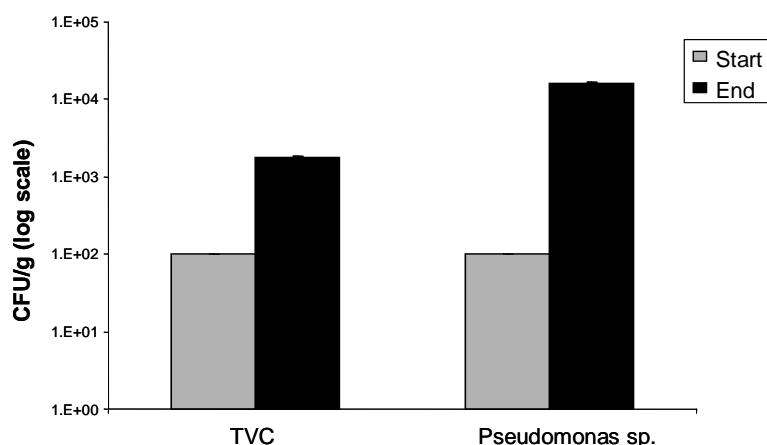
Figure 16. Different types of bacteria (TVC: total bacterial load and *Pseudomonas* sp.) in water collected from the Crustastun chamber before and after 7 cycles of operation (30 animals killed). Values are the mean ± S.E.M. of three different determinations.

Sensory Evaluation of langoustines killed with Crustastun

Sensory evaluations of langoustine tail muscle samples were carried out by a trained professional panel. The scores obtained are shown in Table 1. Samples from Crustastun-killed langoustines scored higher in smell strength and lower in firmness and chewiness. For the other parameters the results were very similar, and no significant differences observed in smell characteristics, springiness, moistness, flavour and aftertaste.

Table 1. Scores obtained on sensory attributes of langoustine cooked meat after being killed on ice or with Crustastun.

		Smell Character.	Smell Strength	Springiness	Firmness	Chewiness	Moistness	Flavour	Aftertaste
Crustastun	Mean	**5.63**	**5.07**	**6.09**	**6.09**	**5.80**	**5.73**	**6.51**	**6.11**
	St. D.	0.39	1.22	2.87	1.09	1.12	0.86	1.28	1.27
On ice	Mean	**5.01**	**3.89**	**5.91**	**7.01**	**7.46**	**5.81**	**6.57**	**6.20**
	St. D.	1.71	2.20	1.44	2.13	2.43	1.09	1.45	1.65

From the comments of the panellists, both samples were perceived as sweet with a sweet aftertaste. However, differences were found in texture attributes. Tail muscle samples from Crustastun-killed langoustines were less firm and chewy (tendencies evaluated as positive). Therefore, the texture of the meat from Crustastun-killed langoustines was described as "nice" or "good" while samples from langoustines killed on ice were described by some panellists as "too chewy" or "rubbery". Possibly because of these textural features, the overall liking was slightly (but not significantly) higher for the samples from Crustastun-killed langoustines compared to those from ice-killed animals (Figure 17).
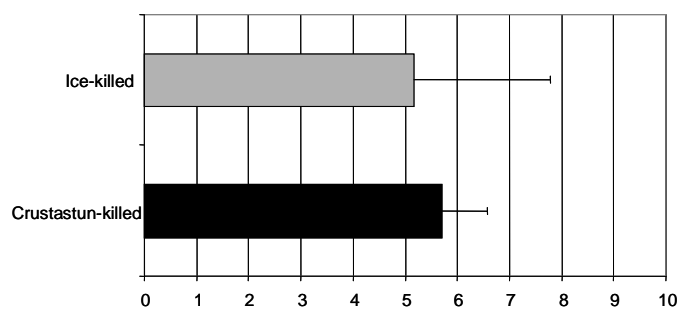
Figure 17. Overall liking of cooked langoustine meat after being Crustastun-killed or ice-killed

Conclusions

- The Crustastun machine was very effective in killing langoustines

- The animals adopted a characteristic tail curvature during the stunning process

- Visual assessment of the langoustines killed using the Crustastun or killed on ice were very similar throughout the storage period studied (7 days).

- The Crustastun process produced an increase in the temperature of the langoustines. This increase was particularly noticeable in the dorsal cephalothorax region, but less so or not at all in the tail.

- The Crustastun-killed langoustines developed black discoloration (melanosis) in the dorsal region of the cephalothorax more rapidly (within 3 days) compared to animals killed on ice. This is ascribed to the temperature increase in these parts, which must either trigger or potentiate the melanosis reactions.

- Post-mortem autolysis progressed more rapidly in the Crustastun-killed langoustines, possibly due to a suppression of gylcolyis by the electrocution process, leading to an acceleration of the breakdown of nucleotides (ATP).

- As a consequence, IMP was the predominant nucleotide from Day 1 in Crustastun-killed langoustines, whereas in ice-killed animals AMP remained high for longer.

- The earlier appearance of IMP in Crustastun-killed langoustines may contribute to a flavour enhancement, if they are consumed within a short period (say 24h) of electrocution.

- The total load of marine (psychotrophic) bacteria was reduced by the Crustastun process, with numbers being lower on Days 1 - 3 of storage.

- However, this lower level of bacteria did not either delay or reduce the appearance of typical products of bacterial spoilage such as hypoxanthine, TMA and biogenic amines, that can affect the quality of the meat

- *Pseudomonas* sp. bacteria numbers were initially higher in the meat of Crustastun-killed langoustines.

- *Pseudomonas* sp. bacteria numbers increased in the brine within the Crustastun chamber after it had been operated for several cycles of electrocution of langoustines.

- Taken together, these results suggest that the brine in the Crustastun chamber should be changed regularly, and that high levels of hygiene should be maintained.

- When meat from Crustastun-killed and ice-killed langoustines was assessed by an independent Sensory Panel, several differences in the objective assessments were reported between the two groups, particularly in some texture parameters. Thus at the time point of 1 day after electrocution, compared to ice-killing, the meat texture of Crustastun-killed langoustines was judged to be less firm and less chewy, features that were evaluated as positive.

- The subjective assessment of the panel in terms of overall liking was also slightly more positive for the Crustasun-killed langoustines, compared to those killed on ice.

Acknowledgements

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Appendices

Appendix 1. Visual assessment scoring table used for langoustines

Attributes	criteria	index points
appearance claws:	carrot orange, white, sharp contrast	0
	orange fading, bleached, dull	1
	light grey, slightly more algae green	2
	bleached , more algae green, creamy/yellowish	3
appearance head:	sharp contrast, carrot orange, pinkish, black eyes	0
	less shiny, bleached, slightly grey, creamy ends	1
	dull, dead, more grey, brownish, bleached eyes	2
	Black, dark grey, dull, grey eyes	3
Uper site tail	Fresh orange, pinkish, white ends, some tail ends already brown	0
	bleached orange, tail ends more grayish and darker brown	1
	light brown over orange, creamy ends, bleached, brown tail ends.	2
	Distinct brown, green lines, black tail ends.	3
Under site tail	Transparent feet, pinkish, translucent meat	0
	discolored feet, milky meat	1
	Brown feet, yellowish meat	2
Odor:	Fresh, hey, marine	0
	Les fresh, neutral	1
	Old seaweed, musty, slightly ammonia	2
	Sour, musty, ammonia	3
Total score		0 - 14

Appendix 2. Melanosis scoring table used for langoustines

1	Total absence of black spots or blackening
2	Few black spots or blackening less than 30 %
3	Considerable blackening (between 30-70 %)
4	Substantial blackening (more than 70 %)